

ADVANCED SYSTEMS CHECKOUT DESIGN

FOURTH QUARTERLY PROGRESS REPORT  
FOR PERIOD MARCH 30, 1966 THRU JUNE 29, 1966

CONTRACT NAS8-20240

PREPARED FOR  
MARSHALL SPACE FLIGHT CENTER  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
HUNTSVILLE, ALABAMA

THE BOEING COMPANY  
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INTRODUCTION

On June 29, 1965, The Boeing Company was awarded Contract NAS8-20240 for the "Advanced Systems Checkout Design" study. This study is to determine what checkout functions can and should be performed on-board the Saturn Instrument Unit and S-IVB stages, how these functions would be mechanized, the impact of these changes on the presently planned Saturn V GSE and schedules, and to develop design guidelines or requirements for incorporating the on-board checkout features.)

The concept of Airborne Evaluation Equipment (AEE) is centered on the use of on-board stage equipment for evaluation of stage status. This concept provides a high degree of stage autonomy as regards testing, providing consistent results through all phases of test and reducing the requirement for support equipment.

SCOPE OF STUDY

The present checkout method for the Saturn vehicle utilizes extensive support equipment to determine vehicle condition, with access through numerous umbilical connections. The equipment being used varies in type and configuration between the various test locations making test data correlation difficult. With the emergence of this vehicle from a developmental status, the test requirements can be more firmly established and the need for acquiring engineering data reduced. With the advances being made in electronics packaging density, size, and power consumption, it is feasible to perform this new scope of testing with a large share of the evaluation equipment located on the vehicle proper. This would also provide relief in correlation of test results between test sites since the test equipment would travel with the vehicle. It would also be available during the mission to perform an in-flight checkout.

This concept places new emphasis on the interface between the vehicle and support equipment. With an on-board checkout system, the bulk of the data reduction and evaluation can occur on the stages under the overall supervisory control of the support complex computer, with status and maintenance information sent to the ground by a data link.

The introduction of this concept will drastically reduce the number of umbilical interconnects and quantity of support equipment, making it easier and less costly to accommodate varying configurations of vehicles at checkout complexes.

The implementation of the AEE concept may well be accomplished in degrees, that is, the first step being the placement of the function satisfying equipment, in a miniaturized form, on the stage and the second step being where the stage subsystem is re-designed to incorporate the function.

## 1.2 STUDY ORGANIZATION

This study, in accord with the work statement, is divided into two phases. Phase A consists of a ten month effort to develop requirements, configuration, and impact of the AEE concept and Phase B, a three month effort to generate the guidelines for its incorporation into a space vehicle system.

## 2.0 PROGRESS AND ANTICIPATED WORK

The Phase A effort was completed April 29. Results obtained were published in Boeing document D5-13257, "Requirements and Implementation - Airborne Evaluation Equipment", and presented to the Q and RA Laboratory, MSFC, in a presentation given May 16. Major topics covered included a description of the proposed on-board test system, program accomplishments, test equipment physical parameters and a phase-in plan. These are summarized below:

The test system configuration for the on-board testing of the S-IVB stage and Instrument Unit consists of a ground computer, guidance computer, digital control unit, three program controllers, and the emergency monitor and control unit. Two program controllers and parts of the emergency monitoring equipment would be located within the S-IVB stage, the remaining on-board equipment would be contained within the Instrument Unit.

Each program controller is fully capable of performing a test or a group of tests, and evaluating the results. It acts under the control of the ground computer or guidance computer dependent on mission phase. The digital control unit provides the interface between the test system and the control computers, it serves as a switch for the routing of data. The emergency monitor and control system provides continuous monitor of selected parameters and initiates control signals in the event an out of tolerance condition develops.

The program controllers are automatic programmer-evaluators, utilizing locally stored instructions to perform stimuli selection, measurement and evaluation mode selection, and evaluation limits. This relieves the control computer memory of the thousands of detailed instructions that can be pre-determined by system specialists and allowing its use, on a time sharing basis, with other functions such as data reduction, formatting for displays and control of other support equipment.

The system follows a testing program determined by the programming mode selected by the test conductor through the computer. In general, a test consists of sequentially selecting a stimulus application point, the response test point, the mode of evaluation for the response, and the evaluation limits. After the test conditions are established, the program controller makes the test connections, waits for a programmed evaluation delay, measures the response, and then evaluates the measured value by comparing it to programmed high and low limits to derive a go or no-go decision. Another feature allows the evaluation of several discrete signals simultaneously as desired. Both the measured value and the evaluation results are available to the control computer.

The test system has three modes of operation: computer programmed, computer sequenced, and computer initiated. These modes allow independent operation of a program controller or complete remote control or a combination of both.

In comparison with current checkout methods, the above configuration considerably reduces the overall test problem. It provides for a reduction of umbilical connectors; the test equipment, parts of which can be integrated with flight equipment, to be located aboard the stage to provide a checkout capability for all vehicle test phases; and provisions of positive control and assessment of vehicle performance.

The umbilical connectors serve a dual purpose, not all can be eliminated by introducing on-board test equipment since some are required for fueling, launch control, etc. However, those used primarily for checkout, approximately 452 wires can be eliminated by utilizing the above equipment.

The program controller can be divided into separate components, control section, response section, switching, and stimuli. The control section containing the test programs must be centrally

located within the stage, but functions of the remaining components can be readily distributed within stage systems providing a degree of self evaluation. This capability will reduce the amount of wiring required for installation and aid during bench testing of the affected vehicle systems.

Control and assessment of vehicle performance is provided through the ground computer or guidance computer, dependent on mission phase, as described above. Both the measured value and evaluation results of each test performed are available to the control computer for distribution to a ground test conductor. The emergency monitor and control system provides continuous monitor of parameters that may indicate an emergency. This data, dependent on vehicle state, is provided to the control computer for action and/or is used to automatically cause a countdown hold or cutoff if conditions warrant, as determined by fixed logic on-board the stage.

The test system was designed to incorporate current vehicle test methods. This will provide the same degree of confidence in vehicle performance following a successful test, and fault isolation to a replaceable assembly in the event of failure as currently available. Improvements are realized, however, due to evaluation now being performed on unconditioned vehicle test parameters near their source. Post launch testing is improved due to the availability of increased data.

The components of the test system were configured to incorporate recent advances in circuit design and packaging techniques to minimize physical parameters. It is estimated the equipment for the Instrument Unit, consisting of the digital control unit, one program-controller and the continuous monitor and control unit will weigh 80 pounds, consume 76 watts average power and require a volume of 1728 cubic inches. The two program controllers for the S-IVB stage will weigh 120 pounds, consume 129 watts average power and require 2592 cubic inches of space. This being accomplished by the utilization of microcircuits that also contribute its reliability.

As regards the generic checkout operations, test data correlation can be performed since all testing involves the same equipment. Also configuration control is more easily accomplished since most of the functional equipment is located on-board the stage.

It is estimated to require approximately 18 months to provide prototype equipment and software for the evaluation of this system. This evaluation could readily be performed using the Saturn V breadbaord facility.

The Phase B effort has been confined to the preparation of the required formal report. This report is being prepared as Boeing Document D5-13279, "Implementation Guidelines, Airborne Evaluation Equipment - Advanced Systems Checkout Design". The current outline is as follows:

- 1.0 INTRODUCTION
- 2.0 TEST SYSTEM REQUIREMENTS
  - 2.1 SYSTEM REQUIREMENTS
  - 2.2 S-IVB STAGE REQUIREMENTS
  - 2.3 IU REQUIREMENTS
  - 2.4 VEHICLE TEST PLANS
- 3.0 TEST SYSTEM DESCRIPTION
  - 3.1 FUNCTIONAL DESCRIPTION
  - 3.2 PHYSICAL DESCRIPTION
- 4.0 IMPLEMENTATION GUIDELINES
  - 4.1 SYSTEM IMPLEMENTATION
  - 4.2 S-IVB STAGE IMPLEMENTATION
  - 4.3 IU IMPLEMENTATION
  - 4.4 SYSTEM PARAMETERS
- 5.0 PASSIVE INSTRUMENTATION APPLICATIONS
- 6.0 RECOMMENDATIONS

3.0 SCHEDULING AND MANNING

A chart containing this information is shown in Figure 1.

4.0 PROBLEMS

None

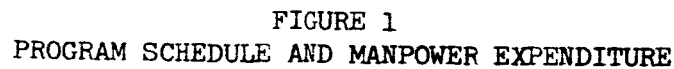


FIGURE 1